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Cadmium Use in Naval Applications

Advanced Surface Engineering Technologies for a Sustainable Defense-Focused Workshop on Cadmium Plating Alternatives

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Dr. Jerilyn Brunson

Naval Surface Warfare Center, Dahlgren Division

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Connectors for Naval Platforms

- Come in a wide variety, i.e., functions, geometries, service environments
  - Electrical
    - Great variety in electrical connectors
  - Fiber optic
  - There will not be a “one size fits all” solution for every connector in the Navy or even every connector on a single ship

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Qualification Tests for Connector Specifications

Qualification tests for connector specifications	MIL-C-81582B	MIL-DTL-3607C	MIL-DTL-21097G	MIL-DTL-21617A	MIL-DTL-22992G	MIL-DTL-26482H	MIL-DTL-28731F	MIL-DTL-28748D	MIL-DTL-32139A	MIL-DTL-55181E	MIL-DTL-83527B	MIL-DTL-38999L	MIL-DTL-83513G	MIL-DTL-24308G	MIL-PRF-64266	MIL-PRF-28876E	SAE-AS-50151	MIL-DTL-28840C	MIL-DTL-83723G	MIL-DTL-12520D	MIL-DTL-25955A	MIL-DTL-27599D	MIL-C-81511F	SAE-AS-81659	SAE-AS-85048A
Physical/ Mechanical																									
Insertion and removal forces																									
Connector/Contact	X					X					X			X	X		X				X				
Assembly/Connectors								X								X									
Board insertion force, overstress			X																						
Crimp contact, MIL-STD-1344, 2012																							X		
Insert strength																									
Axial										X															
Radial										X															
Bond			X			X						X													
Assembly										X															

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Qualification Tests for Connector Specifications (Cont'd)

Qualification tests for connector specifications	MIL-C-81582B	MIL-DTL-3607C	MIL-DTL-21097G	MIL-DTL-21617A	MIL-DTL-22992G	MIL-DTL-26482H	MIL-DTL-28731F	MIL-DTL-28748D	MIL-DTL-32139A	MIL-DTL-55181E	MIL-DTL-83527B	MIL-DTL-38999L	MIL-DTL-83513G	MIL-DTL-24308G	MIL-PRF-64266	MIL-PRF-28876E	SAE-AS-50151	MIL-DTL-28840C	MIL-DTL-83723G	MIL-DTL-12520D	MIL-DTL-25955A	MIL-DTL-27599D	MIL-C-81511F	SAE-AS-81659	SAE-AS-85048A
Physical/ Mechanical																									
Insert retention																									
EIA-364-35											X			X					X			X			
Radial, variable or unspecified															X	X			X						
Axial load, variable or unspecified					X	X									X	X									
Axial load, 50 lbs													X												
Axial load, 60 lbs				X																					
Axial load, 75 lbs	X																								
Axial load, 100 lbs												X										X			
Axial load, 400 lbs																				X					
Radial load, 150 in-lbs																				X					
Mated torque, 150 in-lbs																				X					
Engaging and separating force																									
Shell/RFI spring finger						X						X										X	X		
Contacts				X			X	X													X		X		
Contacts, MIL-C-39029																							X		
Connector/Contacts	X		X		X	X			X			X	X	X	X	X		X							
Connector/Contacts, EIA-364-37																						X			
Assembly/Connectors			X																						
Disengagement only, axial																	X								
Life cycle																									X

Specifications and Performance Requirements

- **Identifying performance requirements naturally guides the selection of an alternative**
  - **What does the connector need to do?**
  - **In what environment?**
- **Changing the specification to allow cadmium alternatives is only one step in the process**

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Allowed Non-Cadmium Plating or Finishes

		Allowed non-cadmium plating or finishes*						
	Cadmium	Electroplated Aluminum	Electroplated ZnNi	Nickel PTFE	Electroless Nickel	Corrosion Resistant Steel	Other**	Status
MIL-DTL-3607C	X	X	X	X	X		Silver, Tin	Active
MIL-DTL-12520D	X					X	Zincated Al w/copper	Not for New Design
MIL-DTL-21097G	X					Passivated		Active
MIL-DTL-21617A	X							Active
MIL-DTL-22992G	X	X	X	X		X	Hard oxide	Active
MIL-DTL-24308G	X	X	X	X	X	Passivated	Zinc, tin, gold	Active
MIL-DTL-25955A	X						Gold, tin	Not for New Design
MIL-DTL-26482H	X	X	X	X	X			Active
MIL-DTL-27599D	X	X	X	X				Not for New Design
MIL-DTL-28731F	X					X		Active
MIL-DTL-28748D	X					Passivated	Zinc, anodized AA	Active
MIL-DTL-28840C	X	X	X	X				Active

*Finishes are typically selected by connector class. Not all finishes or plating are available for all classes of connectors; some classes still require cadmium to meet performance requirements but others could be replaced by currently allowed alternative plating and/or finish classes.

** Other finishes or plating may only be appropriate for a limited selection of parts, e.g., contacts, and not allowable on backshells. Performance specifications do not explicitly specify plating, only that they must meet performance requirements.

†A qualified connector with alternative plating is available.

Allowed Non-Cadmium Plating or Finishes (Cont'd)

		Allowed non-cadmium platings or finishes*						
	Cadmium	Electroplated Aluminum	Electroplated ZnNi	Nickel PTFE	Electroless Nickel	Corrosion Resistant Steel	Other**	Status
MIL-DTL-32139A	X	X	X	X	X	Passivated	Titanium	Active
MIL-DTL-38999L	X	X	X†	X†	X†	Passivated	Tin, anodized	Active
MIL-DTL-55181E	X				X	Passivated		Active
MIL-C-81511F	X				X		Tin	Not for New Design
MIL-C-81582B	X							Active
MIL-DTL-83513G	X	X	X	X	X	Passivated		Active
MIL-DTL-83527B	X							Active
MIL-DTL-83723G	X	X	X	X	X	Passivated	Tin, anodized AA	Active
MIL-PRF-28876E	Compatible					Passivated	Any	Active
MIL-PRF-64266						Passivated	Any	Active
SAE-AS-50151	X				X	Passivated	Tin	Active
SAE-AS-81659	X				X			Active
SAE-AS-85049A	X	X	X	X	X	Passivated	Black anodize	Active

*Finishes are typically selected by connector class. Not all finishes or plating are available for all classes of connectors; some classes still require cadmium to meet performance requirements but others could be replaced by currently allowed alternative plating and/or finish classes.

** Other finishes or plating may only be appropriate for a limited selection of parts, e.g., contacts, and not allowable on backshells. Performance specifications do not explicitly specify plating, only that they must meet performance requirements.

†A qualified connector with alternative plating is available.

Selecting a Cadmium Alternative

- **Direction has been given to eliminate cadmium and hexavalent chromium from all connectors**
  - **Many programs face conflicting requirements that require waivers**
  - **Alternatives selected on the basis of availability rather than performance**
    - **Different programs are making different choices**
    - **Those tasked with making selections often know very little about their options**

Selecting a Cadmium Alternative (Cont'd)

- **Information required to make a selection**
  - **What options are available?**
    - **Has the specification been updated?**
- **What options may be suitable for the connector's performance requirements?**
  - **What testing has been done?**
- **Will changing the plating material require additional specification changes?**

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Example

	Salt Spray	Ext. Salt Spray	Cyclic Salt spray	SO2/Salt Spray	Galvanic corrosion
Scribed	Parallax/ AlumiPlate Boeing/Raytheon	CTC Parallax/ AlumiPlate		CTC Parallax/ AlumiPlate	Boeing/Raytheon
Bare		Parallax/ AlumiPlate			
Lubricant	Amphenol				
Nickel Prestrike		Parallax/ AlumiPlate			
Cu Underplate	Amphenol	CTC Parallax/ AlumiPlate		CTC Parallax/ AlumiPlate NAVAIR Amphenol	CTC NAVAIR Boeing/Raytheon
C^{6+}	Parallax/ AlumiPlate NAVAIR Boeing/Raytheon			Parallax/ AlumiPlate	
C^{3+}	Parallax/ AlumiPlate	Parallax/ AlumiPlate			
SafeGard CC-3400		Parallax/ AlumiPlate			
Alodine 5200		CTC Parallax/ AlumiPlate		CTC Parallax/ AlumiPlate	
Bronze					
CRES/ Stainless					
4130 steel	Parallax/ AlumiPlate				
4340 steel	NAWCAD				
Steel (other, unspecified)					
Titanium				NAVAIR Amphenol	NAVAIR Boeing/Raytheon
Aluminum (6061, 2024, 7075, other)	NAVAIR Amphenol Boeing/Raytheon			Amphenol	
Composite/PEEK	NAVAIR Amphenol				Boeing/Raytheon
Other (AlBeMet. CuBe, other alloy)	Boeing/Raytheon	CTC Parallax/ AlumiPlate		CTC Parallax/ AlumiPlate	

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Example (Cont'd)

	Salt Spray	Ext. Salt Spray	Cyclic Salt spray	SO2/Salt Spray	Galvanic corrosion
Scribed	Parallax/ AlumiPlate Boeing/Raytheon	CTC Parallax/ AlumiPlate		CTC Parallax/ AlumiPlate	Boeing/Raytheon
Coupons/Bars	Parallax/ AlumiPlate NAWCAD			NAVAIR Amphenol	NAVAIR Boeing/Raytheon
Connectors	NAVAIR Amphenol Boeing/Raytheon		CTC		CTC
Fasteners/Other	CTC			Amphenol	
MIL-DTL-38999K-L	Amphenol			Amphenol	
MIL-DTL-5015	Amphenol			NAVAIR	NAVAIR
MIL-PRF-64266	NAVAIR				Boeing/Raytheon
MIL-DTL-83488	Boeing/Raytheon				
MIL-PRF-24308					
MIL-C-83513					

Meeting all Requirements

- **Once an alternative is selected, qualification testing must occur**
  - **Verify the alternative meets performance requirements**
  - **Verify the alternative does not introduce performance requirements**
    - **Or allow for material performance deviations and mitigate impact**

Testing Beyond Corrosion: MIL-PRF-28876E

- Life aging
- Mating and unmating force/ coupling torque
- Backshell and insert retention nut attachment
- Temperature cycling
- Temperature/humidity cycling
- Thermal shock
- External bending moment
- Mating durability
- Impact
- Corrosion (500 hrs salt spray exposure
- Fluid immersion
- Vibration: sine
- Shock: high impact
- Galvanic compatibility
- Dust (fine sand)
- Electromagnetic interference effects
- Cyclic corrosion*

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Ongoing Work

- The work of a cadmium archivist is never done
  - Over 600 gathered documents remain for review; anticipate an order of magnitude more that remain uncollected
- Information must be in an easily accessible form to aid programs in making decisions
  - Searchable databases
  - Identification and incorporation of emerging alternatives

Final Thoughts

- Changing specifications is only one step
- Only testing can determine if an alternative is suitable for use
  - Selection must be performance based as well as availability based
  - Identify unanticipated issues
- Gathering information and making it available leads to smarter long-term program decisions for the Navy and the Department of Defense

Questions?